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APPLIED ENGINEERING AND TECHNOLOGY DIRECTORATE

Earth Observing - 1

Landsat - 7

Interface Control Document

~~November~~ January ~~1999~~2000

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

EO - 1

Landsat - 7

Interface Control Document

~~November 1999~~January 2000

EO-1 MISSION OPERATIONS CENTER

CODE 426

LANDSAT-7 MISSION OPERATIONS CENTER

CODE 428

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EO - 1

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Preface

This document was prepared by members of the Guidance Navigation and Control Center (GNCC) / Flight Dynamics Analysis Branch who support the Landsat-7 Project and the New Millennium Program (NMP)~~NMP~~ Earth Observing-1 (EO-1) Project. The principal goal being sought is to facilitate an accurate and reliable exchange of deliverables between the Landsat-7 Mission Operations Center (MOC) and the EO-1 MOC in order to meet Enhanced Formation Flying requirements between these two spacecraft. An additional purpose is to document the access to Landsat-7 cloud prediction data by EO-1 for image scheduling and for post imaging cloud cover assessment of Landsat-7 images.

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Abstract

The EO-1 spacecraft is required to operate in a specific formation with the Landsat-7 spacecraft during most of its lifetime. During this interval EO-1 is to maintain its location at 1 minute, +/- 6 seconds behind Landsat-7 in the along track direction and within +/- 3 kilometers cross track. In addition, the Mean Local Times at the descending nodes of the two spacecraft are to stay approximately 1 minute apart with EO-1 trailing Landsat-7.

To accomplish the maintenance of this formation, the EO-1 Flight Operations Team must know the current position of Landsat-7, as well as~~,~~ near term plans for Landsat-7 orbit maneuvers.

This ICD will document those deliverables required by the EO-1 operations team to keep EO-1 in the aforementioned formation.

Additionally, this ICD will document the access that EO-1 has to Landsat-7 Cloud Cover Predicts and the Landsat-7 ~~posting imaging~~Post-imaging Cloud Cover Assessment.

Keywords: EO-1, formation flying, orbit maneuvers, cloud cover predicts

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Section 1. Introduction

This document presents the interface for deliverables between the Landsat-7 Mission Operations Center (MOC) and the EO-1 Mission Operations Center (MOC) for the purpose of supporting Formation Flying of these spacecraft. To maintain the required formation between Landsat-7 and EO-1, the orbit control algorithms used to maneuver EO-1 must accurately know the location both present and future for Landsat-7. This will be accomplished by receiving several products from the Landsat-7 MOC on a regular basis. EO-1 is providing FreeFlyer scripts to the Landsat-7 MOC to generate the FreeFlyer products requested by EO-1.

~~EO-1 is providing FreeFlyer scripts to the Landsat-7 MOC to generate the FreeFlyer products requested by EO-1.~~

It is the intent of this document to list the required Landsat-7 deliverables, to present an agreed upon delivery schedule and to detail the method for delivery.

Definitions and acronyms used in this document and a list of references cited are given following Section 3.

1.1 EO-1 Orbit Maintenance Philosophy

The basis for determining the product delivery interface between Landsat-7 and EO-1 is primarily determined by the orbit maintenance philosophy that EO-1 must use to maintain the required formation with Landsat-7. Landsat-7 will assume the lead in planning and executing an orbit maneuver philosophy for itself and EO-1 will be reactive to maintain the formation. The Landsat-7 orbit maintenance philosophy for Ground Track Control (GTC) is to perform a maneuver every 3-4 weeks on a Tuesday. Landsat-7 may choose to change the interval between GTC maneuvers, e.g. they could be performed weekly, but they should be executed on a Tuesday. Inclination maneuvers will be performed when necessary, but should be many months apart.

To maintain the formation with Landsat-7, EO-1 will require the latest available Landsat-7 orbit state and planning information for the next ~~several~~ 6 weeks of Landsat-7 orbit adjust maneuvers. In addition, detailed information about the Landsat-7 force modeling and environmental file will be required to adequately propagate Landsat-7 in the EO-1 Enhanced

Formation Flying (EFF) software.

During the first few months of EO-1 operations, the computations to control EFF between EO-1 and Landsat-7 will be conducted on the ground in the EO-1 -MOC. Using the AUTOCON-G software the EO-1 Flight Operations Team (FOT) will input Landsat-7 information along with that from EO-1 and determine when EO-1 orbit maneuvers are required. After the first few months EO-1 will utilize the AUTOCON-F algorithm in flight software to control EFF. When AUTOCON-F is controlling the EFF, Landsat-7 state vectors must be uplinked to the EO-1 spacecraft. The products to be delivered across this interface will be required as long as EO-1 and Landsat-7 are to maintain their formation.

Section 2. Landsat-7 Deliverables to EO-1

The Landsat-7 deliverables required by the EO-1 -MOC to maintain EFF with Landsat-7 are detailed below and summarized in Table 2-1. Also, those Landsat-7 cloud cover products required to schedule and evaluate EO-1 co-fly images with Landsat-7 are documented below. If any deliverables from Landsat-7 are not received when expected, the EO-1 -MOC will check on their status by telephone. Phone numbers for both the Landsat-~~7~~ 7 MOC and the EO-1 MOC~~s~~ are listed in Section 3.

2.1 Landsat-7 State ~~Vectors~~Vector Files

Landsat-7 will provide an updated orbit state vector to EO-1 following each orbit determination solution. Landsat-7 will perform orbit determinations every day with these orbit solutions anchored at 1200 (UTC) on the day the solution is computed. The drag coefficient, C_D, solved for in each Landsat-7 orbit determination solution must be supplied to EO-1. The Landsat-7 drag coefficient ~~will be~~is contained in the state vector file which is delivered following every -Landsat-7 orbit determination. Also, required is an ignition state vector for every Landsat-7 orbit maneuver planned. All Landsat-7 state vectors will be delivered in the geocentric Mean of J2000 coordinate system using Cartesian elements. The format will be that of a FreeFlyer state file. FreeFlyer is the commercial version of AUTOCON-G, thus this file format will be compatible. ~~All Landsat-7 state vectors will be delivered in the geocentric Mean of J2000 coordinate system using Cartesian elements. The format will be that of a FreeFlyer State file. FreeFlyer is the commercial version of AUTOCON-G, thus this file format will be compatible.~~ See Reference 1. The state vector file format is shown in Table 2-2.

2.2 Landsat-7 Propellant Tank File

To keep the Landsat-7 spacecraft mass updated, the Landsat-7 propellant tank file is at required with each set of maneuver ignition vectors. The format of the Landsat-7 propellant tank file format is shown in Table 2-3.

2.3 Landsat-7 Maneuver Object File(s) and Predicted Ephemeris File

For obtaining knowledge of all future Landsat-7 orbit maneuvers, including both GTC and inclination maneuvers, the Landsat-7 MOC will provide a set of Landsat-7 Maneuver Object files from FreeFlyer. ~~*EO-1 is providing FreeFlyer scripts to the Landsat-7 MOC to*~~

~~*generate the FreeFlyer products requested by EO-1.*~~

When FreeFlyer is run to tentatively plan future Landsat-7 maneuvers, a set of maneuver object files is generated which gives the preliminary ignition time, duration and delta-V magnitude and direction ~~of~~ for these future maneuvers. The use of impulsive maneuver modeling for the Landsat-7 products provided to EO-1 should be adequate. Impulsive modeling makes good sense for the small GTC burns and will simplify the Landsat-7 MOC's efforts to generate the EO-1 products. When Landsat-7 must plan an inclination maneuver, the maneuver object file should be generated using a finite maneuver. In the EO-1 MOC, AUTOCON-G can ingest these FreeFlyer files to provide information about future Landsat-7 orbit maneuver operations.

These Landsat-7 Maneuver Object files will be delivered on Wednesday and should be generated with the latest Landsat-7 orbit solution vector. The coordinate system used for this deliverable will be geocentric Mean of J2000 and should provide information on probable Landsat-7 maneuvers covering the next 6 weeks. This deliverable will continue as long as Landsat-7 and EO-1 are required to fly in formation. The format of this product will be that of the FreeFlyer Maneuver Object File and is shown in Table 2-4. While providing the Landsat-7 Maneuver Object files, a STK e.file ephemeris can be generated simultaneously. The format of this product is shown in Table 2-5. This Landsat-7 orbit ephemeris, which reflects the orbit maneuvers planned for the next
-6 weeks should be delivered with the Maneuver Object files.

2.4 Landsat-7 Orbit Maintenance Report

To confirm that a planned Landsat-7 orbit maneuver was executed, the EO-1 MOC needs to receive notification that the maneuver occurred. This notification is required on the day following every Landsat-7 orbit maneuver. This product will be in the form of a spreadsheet that will be E-mailed to the EO-1 MOC at the following address: eo1fot@bullseye.nascom.nasa.gov. The format for this product is shown in Table 2-~~5~~6.

2.5 ~~2.5~~ Landsat-7 Ascending Node Times and Pass Number File

To correctly specify the Landsat-7 pass number in the EO-1 Flight Dynamics Support Subsystem (FDSS) product known as the Landsat-7 Maneuver Planning file, Landsat-7 must supply pass numbers. The Landsat-7 MOC already generates a product using the Satellite Tool Kit software which meets this need. This product, known as Ascending Node (AN) Times and Pass Number will be perfectly suited to supply this information to the EO-1 MOC for EFF planning. The report will be delivered weekly or whenever a new Ascending Node (AN) -report is computed. Duration is 28 days and the format is shown in Table 2-~~6~~7. See

Reference 2, page 3-22.

2.6 Landsat-7 Mean Local Time at the Descending Node File

To meet the EFF requirement that EO-1 be 1 minute behind Landsat-7 in Mean Local Time (MLT) at the descending node (DN), the EO-1 MOC needs information on the Landsat-7 MLT at the DN. EO-1 will provide to the Landsat-7 MOC a FreeFlyer script that computes a prediction of the Landsat-7 MLT at the DN. This product will be six weeks in duration and delivered on the same day as the AN report. This delivery will continue as long as Landsat-7 and EO-1 are required to fly in formation. The format of this product is shown in Table 2-~~7~~8.

2.7 Landsat-7 Force Models and Environmental Files for Orbit Propagation

In order to correctly propagate the Landsat-7 state vectors for EFF planning, it is essential that the EO-1 MOC use exactly the same force models and environmental files that Landsat-7 is using for orbit propagation in FreeFlyer. To assure like accuracies in orbit propagation results, there must be initial verification that both The Landsat-7 MOC and the EO-1 MOC~~s~~ use the same force modeling and environmental files in FreeFlyer. Once, both spacecraft are flying, a monthly check of these parameters should be performed. A checklist will be prepared by the EO-1 MOC and delivered to the Landsat-7 MOC for verification/updating. The checklist format is shown in Table 2-~~8~~9.

2.8 Landsat-7 Cloud Cover Products for Co-imaging with EO-1

The EO-1 MOC will ingest the same predicts provided by National Oceanic and Atmospheric Administration (NOAA) National Center for Environmental Predicts (NCEP)

that Landsat-7 uses to perform predictive cloud cover assessment. The EO-1 Mission Operations Planning and Scheduling System (MOPSS) will be modified to ingest NCEP cloud cover data, use these predicts to calculate and display predicted cloud coverage for requested targets, compare predicted cloud cover to maximum allowable cloud coverage thresholds as specified in requests, and display requests which exceed allowable cloud coverage as in constraint. (Reuse of Landsat-7 software is anticipated.) Down-selection of prime and alternate requests based on cloud coverage to the final EO-1 targets that will be uplinked and collected by EO-1 will be done daily (M-F) by the EO-1 FOT and will be done manually. Load planning will be done during the day shift and will based on latest available NCEP data [ie, typically w/ epoch at 1200Z (7 AM local, Eastern Standard Time (EST)]). The EO-1 FFOT will check the cloud thresholds of the EO-1 scenes against cloud predicts and drop those scenes that do not meet cloud cover requirements.

Cloud Cover is the percentage of the entire image obscured by clouds and their shadows. Cloud coverage will be calculated to a resolution of 1 %.

EO-1 will go directly to the NOAA NCEP server (ftp.ncep.noaa.gov) to retrieve cloud coverage data. Specifically EO-1 will pull T##Z.SFLUXGrbF** files (where ## is the predict epoch hour and ** is the predict offset hour from the epoch) located in the /pub/data1/avn/avn.*yymmdd* subdirectory (where *yymmdd* is date of interest)

2.9 Landsat-7 Daily Target List

The EO-1 FOT will ~~receive~~ retrieve the Landsat-7 target list daily (available on the web ~2-3pm). The web address is: http://ls7pm3.gsfc.nasa.gov/scenes. The scene requests to the EO-1 MOC will have a 'paired scene abort' parameter to cancel a Data Collection Event (DCE) if Landsat-7 is not planning to take the scene. This abort will be used if time to respond and generate a new command load is available. If the abort is exercised the scene will be replaced with another from the prioritized list. This too will be a manual process. In its post-image analysis process, the Mission Science Office (MSO) will review available data image statistics from Landsat-7 imagery to determine if the target was sufficiently cloud free to be acceptable. The Landsat-7 MOC will notify the EO-1 MOC if the daily scheduled list is late or not done at all. This notification should be made by phone on 301-286-2686.

2-10: Landsat-7 Automated Cloud Cover Assessment Scores~~2.10 Landsat-7 Automatic Cloud Cover Assessment Scores~~

In its post-image analysis process, the MSO will review available data image statistics from Landsat-7 imagery to determine if the target was sufficiently cloud free to be acceptable. Landsat-7 will provide Automated Cloud Cover Assessment (ACCA) scenes to EO-1 in the format shown in Table 2-10.~~See Table 2-9~~10.

The simplest and cheapest (i.e., free) method for EO-1 to obtain Landsat-7 Automatic Cloud Cover Assessment (ACCA) score data is via the WWW/~~EOS~~ Earth Obsaerving System (EOS) Data Gateway (EDG) interface. The MSO can browse the Landsat-7 metadata and collect the scores as the data is processed by the Data Handling Facility (DHF) and archived in the Earth Observing System Data and Information System (EOSDIS) Core System (ECS). This method, however, is not satisfactory for operational use because 1) searches are time consuming, and 2) due to server loads on ECS data centers, searches may be unsuccessful with no indication given to the user that server loads are the cause of the unsuccessful search.

The Landsat-7 MOC at Goddard Space Flight Center (GSFC) gets the ACCA scores (embedded in their metadata) daily via ~~ftp~~File Transfer Protocol (FTP) from Earth Resources Observation System (EROS) Data Center (EDC). The scores are available within 24 hours of receipt of the data in the
Landsat-7 Processing System. The 24 hour turn around expectation is reasonable for those scenes down linked at the Landsat Ground Station (Sioux Falls, SD) (LGS) System (significant latency is involved with Alaska Ground Station (AGS) or Svalbard Ground Station (Svalbard, Norway) (SGS) acquisitions). The Landsat-7 MOC then extracts the ACCA data and closes its accounting for scenes. Landsat-7 ops personnel have modified the contents of a configuration table which is user-specified. This table in turn tells Flight Dynamics Facility (FDF) Orbital and Mission Aids Transformation System (FORMATS) to place the ACCA data on the open server for EO-1 to retrieve. The address and directory information for the open server will be provided by the Landsat-7 MOC to the EO-1 MOC in a private ~~m~~memorandum.~~has an IP address of 150.144.204.137 and the data is in directory ls7/ProductRepository/Outbound/EO1/Products. Landsat-7 is providing a backup server at 150.144.204.138 which is only to be used if the primary server is down.~~

Table 2-1: Landsat-7 Deliverables to EO-1

Deliverable	Performance Specification
Landsat-7 state vector files	**Frequency:** After every Landsat-7 orbit determination the solution state vector in a file with the C_D will be delivered daily by 11:00 AM. Also, every Wednesday the state vectors for the planned ignition time for every Landsat-7 orbit maneuver occurring during the next six weeks will be delivered by 12:00 noon **Accuracy:** Best available **Timespan:** A single state vector at the anchor time of ~~the~~ every tracking data arc and at ignition time for every Landsat-7 orbit maneuver planned over the next 6 weeks.
Landsat-7 propellant tank file	**Frequency:** Every Wednesday the ~~current~~ initial and final propellant tank files for the next 6 weeks of planned maneuvers will be delivered by 12:00 noon. **Accuracy:** Best available **Timespan**: Not applicable

Table 2-1: Landsat-7 Deliverables to EO-1 (Continued)

Deliverable	Performance Specification
Landsat-7 maneuver object files ~~and predicted STK e.file ephemeris containing planned maneuvers~~	**Frequency:** Weekly, on Wednesday by 12:00 noon **Accuracy:** Based on best available Landsat-7 future orbit maneuver plan at delivery **Timespan:** One maneuver object file for each orbit maneuver planned during the next 6 weeks~~, plus the 6 week STK e.file orbit ephemeris containing all planned maneuvers~~
Landsat-7 predicted STK e.file ephemeris containing planned maneuvers	**Frequency:** Weekly, on Wednesday by 12:00 noon **Accuracy:** Based on best available Landsat-7 future orbit maneuver plan at delivery **Timespan:** The 6 week STK e.file orbit ephemeris containing all planned maneuvers
Landsat-7 ascending node times and pass numbers file	**Frequency:** Weekly, on Wednesday by 12:00 noon **Accuracy:** Best available **Timespan:** Twenty-eight days

Landsat-7 mean local times at the descending node file	**Frequency:** Weekly, on Wednesday by 12:00 noon **Accuracy:** Best available **Timespan:** Six weeks ahead
Landsat-7 orbit maintenance report (E-Mail)	**Frequency:** By 12:00 noon the day following the maneuver **Accuracy:** Best available **Timespan:** Not applicable

Table 2-1: Landsat-7 Deliverables to EO-1 (Continued)

Verification of Landsat-7 force models and environmental files for orbit propagation	**Frequency:** Pre-launch, then monthly or whenever updates occur **Accuracy:** Best available **Timespan:** Not applicable
NCEP predicted cloud coverage used by Landsat-7 (NOTE: received directly from NOAA NCEP website)	**Frequency:** Daily **Accuracy:** As provided by NOAA NCEP **Timespan:** 48 hours +
Landsat-7 daily target list (available on a WWW site)	**Frequency:** Daily (Monday-Friday) **Accuracy:** Best available **Timespan:** 1 day

Landsat-7 post imaging cloud cover ratings	**Frequency:** For all co-fly images with Landsat-7 **Accuracy:** As provided by EDC to Landsat-7 **Timespan:** As provided by EDC

Table 2-2: Landsat-7 State File Format

```
Spacecraft "Landsat7"
{
  Epoch               = "Jan 04 2000 14:45:57.131",
  X                   = -1245.5283309826,
  Y                   = -6209.2001762612,
  Z                   = 3163.12913421135,
  VX                  = -1.82304789971226,
  VY                  = -3.0210282305835,
  VZ                  = -6.62502872629573,
  AX                  =                0,
  AY                  =                0,
  AZ                  =                0,
  Mass                = 1969.13957910203,
  MassRate            =                0,
  MassDotDot          =                0,
  CentralBody         =                3,
  Cd                  =              2.2,
  Cr                  =              1.4,
  Cl                  =              1.2,
  DragArea            =            15.21,
  LiftArea            =                1,
  SRPArea             =                1,
  Yaw                 =                0,
  Roll                =                0,
  Pitch               =                0,
  Q1                  =                0,
  Q2                  =                0,
  Q3                  =                0,
  Q4                  =                1,
  AttitudeSource      =                0,
  Color               =          3407667,
  MaskType            = "None",
  ConeAngle           =               70,
  PointsInMask        =                0,
  VehicleDryMass      = 1855.13957910203,
  VehicleDryCOGX      =                0,
  VehicleDryCOGY      =                0,
  VehicleDryCOGZ      =                0,
  VehicleCOGX         =                0,
  VehicleCOGY         =                0,
  VehicleCOGZ         =                0,
  VehicleDryIXX       =             1200,
  VehicleDryIXY       =                0,
  VehicleDryIXZ       =                0,
  VehicleDryIYX       =                0,
  VehicleDryIYY       =             1200,
  VehicleDryIYZ       =                0,
  VehicleDryIZX       =                0,
  VehicleDryIZY       =                0,
  VehicleDryIZZ       =             1200,
  VehicleIXX          =             1200,
  VehicleIXY          =                0,
  VehicleIXZ          =                0,
```

```
  VehicleIYX           =              0,
  VehicleIYY           =           1200,
  VehicleIYZ           =              0,
  VehicleIZX           =              0,
  VehicleIZY           =              0,
  VehicleIZZ           =           1200,
};
```

Table 2-3: Landsat-7 Propellant Tank File Format

```
SphericalTank "LS7_Tank"
{
  TankRefX             =               0,
  TankRefY             =               0,
  TankRefZ             =               1,
  TankOrientX          =               0,
  TankOrientY          =               0,
  TankOrientZ          =               1,
  TankMass             = 112.157677365386,
  TankCOGX             =               0,
  TankCOGY             =               0,
  TankCOGZ             = 0.892558363322747,
  TankIXX              = 2.23679756665161,
  TankIXY              =               0,
  TankIXZ              =               0,
  TankIYX              =               0,
  TankIYY              = 2.23679756665161,
  TankIYZ              =               0,
  TankIZX              =               0,
  TankIZY              =               0,
  TankIZZ              = 77.6543081002327,
  TankOrient2X         =               0,
  TankOrient2Y         =               0,
  TankOrient2Z         =               0,
  TankPressure         = 1523.29842916196,
  TankTemperature      =            15.5,
  TankRefTemperature   =              21,
  TankVolume           =  0.186326549586,
  TankFuelDensity      =     1007.579533,
};
```

Table 2-4: Landsat-7 Maneuver Object File Format

```
ImpulsiveBurn "GTCBurn1"
{
AttitudeSystem       =               1,
X-Component          = 3.4325861484272e-05,
Y-Component          =               0,
Z-Component          =               0,
SpecificImpulse      =             220,
ManeuverGravityConstant =            9.81,
ManeuverStartTime    =               0,
BurnDuration         =               0,
ThrustScaleFactor    =               1,
};
```

Table 2-5: Landsat-7 Predicted Orbit Ephemeris File Format

```
stk.v.3.0

BEGIN Ephemeris

    NumberOfEphemerisPoints 50401
    ScenarioEpoch 11 Dec 1999 00:00:00.000
    EphemerisEciTimePosVel
0.000 -2745047.848 -4454339.000 4764472.954 -3839.621452 -3466.613036 -5439.088023
60.000 -2969723.065 -4653194.595 4428695.006 -3647.024057 -3159.665287 -5749.737613
120.000 -3182395.280 -4833242.433 4074969.586 -3439.655954 -2839.899283 -6037.133034
180.000 -3382203.082 -4993752.009 3704727.725 -3218.354915 -2508.609925 -6300.097576
240.000 -3568337.097 -5134072.008 3319468.125 -2984.017101 -2167.141202 -6537.553165
300.000 -3740043.386 -5253633.095 2920751.087 -2737.593598 -1816.880865 -6748.525295
360.000 -3896626.630 -5351950.378 2510192.159 -2480.086716 -1459.254940 -6932.147725
420.000 -4037453.086 -5428625.527 2089455.500 -2212.545980 -1095.721838 -7087.667045
480.000 -4161953.290 -5483348.527 1660246.985 -1936.063600 -727.765779 -7214.446811
540.000 -4269624.461 -5515899.014 1224307.083 -1651.769445 -356.889782 -7311.970626
600.000 -4360032.616 -5526147.198 783403.599 -1360.825869 15.391164 -7379.844099
660.000 -4432814.358 -5514054.388 339324.302 -1064.422675 387.556432 -7417.796201
720.000 -4487678.379 -5479673.146 -106130.507 -763.772144 758.085942 -7425.680578
780.000 -4524406.652 -5423147.059 -551155.517 -460.103812 1125.466750 -7403.476660
840.000 -4542855.302 -5344710.100 -993947.968 -154.658948 1488.200052 -7351.290013
900.000 -4542955.141 -5244685.574 -1432715.202 151.315134 1844.808221 -7269.351680
960.000 -4524711.858 -5123484.634 -1865682.155 456.570770 2193.841532 -7158.016678
1020.000 -4488205.871 -4981604.422 -2291098.728 759.865634 2533.884578 -7017.761834
1080.000 -4433591.837 -4819625.821 -2707247.017 1059.968299 2863.562374 -6849.182918
1140.000 -4361097.838 -4638210.853 -3112448.346 1355.663515 3181.546087 -6652.991130
1200.000 -4271024.264 -4438099.757 -3505070.078 1645.757135 3486.558335 -6430.009226
1260.000 -4163742.399 -4220107.741 -3883532.186 1929.080962 3777.378241 -6181.167426
1320.000 -4039692.715 -3985121.449 -4246313.568 2204.497658 4052.846288 -5907.498794
1380.000 -3899382.884 -3734095.145 -4591958.055 2470.905467 4311.868698 -5610.133884
1440.000 -3743385.506 -3468046.654 -4919080.096 2727.242354 4553.421076 -5290.294967
1500.000 -3572335.626 -3188053.105 -5226370.086 2972.489575 4776.551522 -4949.290497
1560.000 -3386928.024 -2895246.489 -5512599.383 3205.675155 4980.383757 -4588.509886
1620.000 -3187914.307 -2590809.021 -5776624.999 3425.877555 5164.120427 -4209.417931
1680.000 -2976099.769 -2275968.313 -6017393.942 3632.229282 5327.046113 -3813.548420
1740.000 -2752340.054 -1951992.389 -6233947.139 3823.919965 5468.529565 -3402.497195
1800.000 -2517537.650 -1620184.580 -6425422.961 4000.198868 5588.025217 -2977.915372
```

o

Table 2-~~5~~6: Landsat-7 Orbit Maintenance Report Format

Burn: OM-6

Burn Start: #########
yyyymmdd.hhmmss

Number of Pulses: 340

Thrusters Used: 2 (2 and 4)

Burn Stop: #########
yyyymmdd.hhmmss

Burn Duration: 17 sec.

Osculation Keplerian	Actual Pre-Burn	Actual Post-Burn	Delta (post-pre)	Pred. Post-Burn	Actual Post-Burn	Delta (post-pred)
Epoch	#########	#########	n/a			
Semimajor Axis (km)	7086.713159	7086.762272	0.0491	7086.751515	7086.762272	0.0108
Eccentricity	0.001174295	0.001154414	-0.00001988	0.001154741	0.001154414	0.0000
Inclination (deg)	98.21162123	98.21165882	0.0000	98.21160031	98.21165882	0.0001
RAAN (deg)	21.85057718	21.85058038	0.0000	21.85033623	21.85058038	0.0002
Arg of Per(deg)	113.1225302	113.815476	0.6929	113.8237884	113.815476	-0.0083
Mean Anomaly (deg)	71.16781247	71.50642933	0.3386	71.50655293	71.50642933	-0.0001
WRS Drift (km/day)			0.0000			0.0000
Brouwer Mean (J2)						
Epoch	#########	#########	n/a			
Semimajor Axis (km)	7077.679529	7077.785159	0.1056	7077.774894	7077.785159	0.0103
Eccentricity	0.001180091	0.001179051	-0.00000104	0.001179477	0.001179051	0.0000
Inclination (deg)	98.21690206	98.2169067	0.0000	98.21684788	98.2169067	0.0001
RAAN (deg)	21.85136402	21.85155842	0.0002	21.85131582	21.85155842	0.0002
Arg of Perigee (deg)	91.10203482	91.82712261	0.7251	91.8446264	91.82712261	-0.0175
Mean Anomaly (deg)	93.18004915	93.48458636	0.3045	93.47550277	93.48458636	0.0091
WRS Drift (km/day)			0.00			0.0000

Apogee Altitude (km)	**707.8868382**	**707.9852281**	**0.10**
Perigee Altitude (km)	**691.1822194**	**691.295089**	**0.11**

Table 2-~~5~~6: Landsat-7 Orbit Maintenance Report Format (Continued)

System Parameters	Used for Planning	Burn Actuals
Duty Cycle	100.00%	100.00%
Thruster Efficiency	93.72%	95.12%
Fuel Used (kg)	0.0509	0.0509
Estimated Fuel Remaining	1966.0020	1966.0020
Pre-Burn Pressure (psi)	215.937	215.937
Post-Burn Pressure (psi)	215.795	215.795
Pre-Burn Temperature	15.5	15.5
Post-Burn Temperature	15.5	15.5

Comments:

Table 2-~~67~~7: Landsat-7 Ascending Node Times and Pass Number File Format

```
"Start","Stop"
005/2000 00:00:00.0000,013/2000 00:00:00.0000
"Pass Number","Start Time (UTCJ4)","End Time (UTCJ4)","Period (sec)","Apogee (km)","Time
of Apogee (UTCJ4)","Perigee (km)","Time of Perigee (UTCJ4)","Right Ascen (deg)","Lon Ascen
Node (deg)","Lon Descen Node (deg)"
294,005/2000 00:00:00.000,005/2000 01:37:06.699,Partial Pass,732.013444,005/2000
01:14:52.686,714.061576,005/2000 00:23:24.372,Not in Pass,Not in Pass,139.356
295,005/2000 01:37:06.699,005/2000 03:15:59.651,5932.952,731.984169,005/2000
02:53:36.636,714.210501,005/2000 02:02:14.880,75.230,306.976,114.636
296,005/2000 03:15:59.651,005/2000 04:54:52.696,5933.045,732.359992,005/2000
04:31:40.672,714.234106,005/2000 03:41:04.947,75.298,282.256,89.916
297,005/2000 04:54:52.696,005/2000 06:33:45.728,5933.032,732.514687,005/2000
06:09:49.774,714.194141,005/2000 05:19:51.221,75.367,257.536,65.195
298,005/2000 06:33:45.728,005/2000 08:12:38.699,5932.971,732.478092,005/2000
07:48:24.411,714.168957,005/2000 06:58:36.751,75.435,232.815,40.474
299,005/2000 08:12:38.699,005/2000 09:51:31.615,5932.916,732.398207,005/2000
09:27:24.316,714.165113,005/2000 08:37:28.161,75.502,208.094,15.753
300,005/2000 09:51:31.615,005/2000 11:30:24.512,5932.897,732.291449,005/2000
11:06:34.390,714.210723,005/2000 10:16:21.165,75.569,183.372,351.032
301,005/2000 11:30:24.512,005/2000 13:09:17.408,5932.896,732.175937,005/2000
12:46:09.438,714.194326,005/2000 11:55:19.222,75.636,158.651,326.311
302,005/2000 13:09:17.408,005/2000 14:48:10.369,5932.961,732.171709,005/2000
14:25:20.646,714.190883,005/2000 13:34:19.196,75.703,133.930,301.591
303,005/2000 14:48:10.369,005/2000 16:27:03.401,5933.032,732.180345,005/2000
16:04:10.945,714.269986,005/2000 15:13:13.489,75.770,109.209,276.869
304,005/2000 16:27:03.401,005/2000 18:05:56.446,5933.045,732.084338,005/2000
17:43:05.189,714.390746,005/2000 16:52:06.167,75.837,84.487,252.148
305,005/2000 18:05:56.446,005/2000 19:44:49.457,5933.011,732.139016,005/2000
19:21:55.707,714.321608,005/2000 18:30:59.298,75.904,59.766,227.426
306,005/2000 19:44:49.457,005/2000 21:23:42.380,5932.923,732.107098,005/2000
21:00:58.141,714.187075,005/2000 20:09:53.444,75.972,35.045,202.705
307,005/2000 21:23:42.380,005/2000 23:02:35.275,5932.895,732.128245,005/2000
22:39:56.635,714.103359,005/2000 21:48:49.183,76.040,10.325,177.985
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Table 2-~~7~~8: Landsat-7 Mean Local Times at Descending Node File Format

LS7.EpochText None	LS7.MltDescendingNode Hours
Aug 21 1999 00:11:36.410	10.102607855
Aug 22 1999 00:54:51.949	10.102614521
Aug 23 1999 01:38:07.477	10.102632410
Aug 24 1999 00:42:29.901	10.102670288
Aug 25 1999 01:25:45.300	10.102686954
Aug 26 1999 00:30:07.650	10.102734308
Aug 27 1999 01:13:23.394	10.102749325
Aug 28 1999 00:17:47.246	10.102796105
Aug 29 1999 01:01:04.112	10.102804955
Aug 30 1999 00:05:27.847	10.102845595
Aug 31 1999 00:48:44.598	10.102846323
Sep 01 1999 01:32:01.305	10.102847155
Sep 02 1999 00:36:24.848	10.102869390
Sep 03 1999 01:19:41.411	10.102859427
Sep 04 1999 00:24:04.861	10.102883674
Sep 05 1999 01:07:21.296	10.102873923
Sep 06 1999 00:11:44.635	10.102904344
Sep 07 1999 00:55:00.949	10.102902186
Sep 08 1999 01:38:17.233	10.102912459
Sep 09 1999 00:42:40.343	10.102942340
Sep 10 1999 01:25:56.454	10.102947925
Sep 11 1999 00:30:19.450	10.102981165
Sep 12 1999 01:13:35.392	10.102977729
Sep 13 1999 00:17:58.253	10.103006021
Sep 14 1999 01:01:14.035	10.102993206
Sep 15 1999 00:05:36.738	10.103013753
Sep 16 1999 00:48:52.359	10.102994930
Sep 17 1999 01:32:07.906	10.102979547
Sep 18 1999 00:36:30.332	10.102989754
Sep 19 1999 01:19:45.663	10.102969835

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Table 2-~~89~~ : Verification of Landsat-7 Force Models & Environmental Files Format

File Name	File Description	File Creation Date	Notes
JGM2.POTENTIAL	Earth Geo-potential Model		Model Size: 21x21 (truncated); GM = 398600.4415 km^3/sec^2; ERAD= 6378.136 km
DE200.DAT	Solar-Lunar-Planetary File Containing Jet Propulsion Laboratory (JPL) Export Ephemeris		
JRNOAA.PC	Jacchia-Roberts Solar Prediction Data Updated Monday, Wednesday and Friday		Landsat-7 Parameters C_D = 2.0 C_R = 1.5 SCMASS = YYYY.YYY KG SCAREA = 15.21 M^2
UT1UTC.DAT	Time Correction File		

~~Table 2-9. Landsat-7 Cloud Cover Assessment for Co-imaging with EO-1~~

~~Table 2-10: Automated Cloud Cover Assessment Scores~~

Table 2-10: Automated Cloud Cover Assessment Scores Format

Path	Row	Scene Center Times	Percent of Cloud Cover Contaminant	Carriage Return
019	016	1999-333T15:57:10.0796170Z	43	C_R
051	020	1999-333T19:16:32.0540540Z	94	C_R
019	048	1999-333T16:09:55.0271180Z	3	C_R
003	070	1999-333T14:39:48.0309720Z	30	C_R
019	049	1999-333T16:10:19.0178840Z	46	C_R
051	023	1999-333T19:17:44.0195960Z	91	C_R
003	071	1999-333T14:40:12.0241820Z	1	C_R
051	024	1999-333T19:18:08.0072860Z	100	C_R
003	072	1999-333T14:40:36.0185400Z	36	C_R
003	073	1999-333T14:41:00.0120790Z	66	C_R
051	070	1999-333T19:36:27.0674840Z	5	C_R
051	071	1999-333T19:36:51.0604740Z	31	C_R
067	241	1999-333T22:23:34.0371510Z	0	C_R
067	242	1999-333T22:23:58.0342960Z	0	C_R
067	243	1999-333T22:24:22.0228760Z	0	C_R
067	244	1999-333T22:24:46.0378690Z	0	C_R

192	029	1999-329T09:51:31.0902800Z	34	C_R
192	034	1999-329T09:53:31.0346300Z	46	C_R
192	035	1999-329T09:53:55.0246000Z	29	C_R
176	080	1999-329T08:32:58.0513930Z	0	C_R
176	081	1999-329T08:33:22.0465730Z	1	C_R
176	082	1999-329T08:33:46.0422240Z	42	C_R
071	016	1999-329T21:18:33.0003300Z	25	C_R
176	083	1999-329T08:34:10.0373310Z	27	C_R

~~As specified in Reference 3, there are five Automatic Cloud Cover Assessment (ACCA) parameters provided in the LPS Metadata File. There is the overall CCA and the CCA for each quadrant.~~

~~Example:~~

~~SCENE_CCA = 52~~
~~UL_QUAD_CCA = 99~~
~~UR_QUAD_CCA = 99~~
~~LL_QUAD_CCA = 4~~
~~LR_QUAD_CCA = 6~~

~~where '0' is clear and '100' is 100% cloudy.~~

Section 3. Method for Transfer of Deliverables

The transfer of deliverables from the Landsat-7 MOC to the EO-1 MOC will be accomplished using Transfer Control Protocol/Internet Protocol (TCP/IP) under ~~File Transfer Protocol (~~FTP~~)~~. The Landsat-7 deliverables for EO-1 will be placed in an accessible file on a Landsat-7 PC (ls7mocpc1) on the open side of the Landsat-7 MOC and will be retrieved by EO-1 MOC personnel. They will have a READ ONLY permission and a naming convention that indicates the product name and the date that the product begins. See Table 3-1.

One additional product, the Landsat-7 Orbit Maintenance Report spreadsheet, will be E-mailed to the EO-1 MOC at the same time as the post Landsat-7 maneuver deliveries are made. This E-mailing will be sent to ~~the lead FDSS member of the EO-1 Flight Operations Team.~~eo1fot@bullseye.nascom.nasa.gov.

~~In the event that voice communications are required between the Landsat-7 and EO-1 MOCs, the following black phone numbers may be used: Landsat-7, 301-614-5203; EO-1, 301-286-2686 or 301-286-4163.~~

3.1 Landsat-7 Product File Names

PRODUCT	PRODUCT NAME
Landsat-7 Orbit Determination State Vector	LS7yyyydddODSTAT.~~Svv~~Svv
Landsat-7 Initial & Final State Vectors for 6 Week Run	L7yyyydddINSTAT.Svv L7yyyydddFLSTAT.Svv
Landsat-7 Predicted Ephemeris (e.file)	LS7yyyydddLS7EPH.Svv
Landsat-7 Pre-ignition State Vectors	LS7yyyydddIGSTAT.Svv
Landsat-7 Initial & Final Propellant Tank Files	L7yyyydddINTANK.Svv L7yyyydddFLTANK.Svv
Landsat-7 Maneuver Object Files	LS7yyyydddMANOBJ.Svv
Landsat-7 Ascending Nodes & Pass Numbers File	LS7yyyydddANODES.Svv
Landsat-7 MLT at Descending Node File	LS7yyyydddDNDMLT.Svv
Landsat-7 Force Model & Environmental File Verification	LS7yyyydddVERIFY.Svv

Landsat-7 Cloud Cover Assessment Rating for Co-imaging with EO-1	~~LS7yyyydddCLOUDSL~~LS~~7~~yyyydd dECSCCA.Svv

~~The verification of force models and environmental files will use a product format which is shown in Table 2-8.~~where: yyyy = year file was generated (2000 – 2100)
ddd = day of year file was generated (001 – 366)
vv = sequence number of file for that day (00 - 99)

where: yyy=year file was generated (2000-2100)

ddd= day of year file was generated (001-366)

vv= sequence number of file for that day (00-99_)

nn =number of the file in a specific set (01, 02, 03,…)

Table 3-1: Landsat-7 File Naming Convention

3.2 Points Of Contact Between The Landsat-7 MOC and The EO-1 MOC

Landsat-7 MOC		EO-1 MOC	
General Phone No.	301-614-5202	General Phone No.	301-286-2686
Flight Dynamics Phone No.	301-614-5203	Flight Dynamics Phone No.	301-286-~~98692686~~ or 301-286-4163
Mission Planner Phone No.	301-614-5541	Mission Planner Phone No.	301-286-4163
Fax No.	301-614-5263	Fax No.	301-286-1732

Table 3-2: Phone Numbers in the Landsat-7 MOC and EO-1 MOC

Abbreviations and Acronyms

ACCA	~~Automatic~~ Automated Cloud Cover Assessment
AGS	Alaska Ground Station (Fairbanks, Alaska)
AN	Ascending Node
CCA	Cloud Cover Assessment
DCE	Data Collection Event
DHF	Data Handling Facility
DN	Descending Node
ECS	Earth Observing System Data and Information System (EOSDIS) Core System
EDC	~~EROS~~ Earth Resources Observation System (EROS) Data Center
EDG	Earth Observing System (EOS) Data Gateway
EFF	Enchanced Formation Flying
EO-1	Earth Observing – 1
EST	Eastern Standard Time
FDSS	Flight Dynamics Support Subsystem
FORMATS	Flight Dynamics Facility (FDF) Orbital and Mission Aids Transformation System
FOT	Flight Operations Team
FTP	File Transfer Protocol
GTC	Ground Track Control
GSFC	Goddard Space Flight Center
IP	Internet Protocol
JPL	Jet Propulsion Laboratory
LGS	Landsat Ground Station (Sioux Falls, SD)
MLT	Mean Local Time
MOC	Mission Operations Center
MOPSS	Mission Operations Planning and Scheduling System
MSO	Mission Science Office
~~NA~~NMP	~~Not Applicable~~New Millennium Program

NOAA	National Oceanographic and Atmospheric Administration
NCEP	National Centers for Environmental Prediction
~~PODS~~	~~Precision Orbit Determination System~~
SGS	~~Norway~~ Svalbard Ground Station (Svalbard, Norway)
TCP/IP	Transfer Control Protocol/Internet Protocol

References

1. FreeFlyer User's Guide, Version 4.0, dated March 1999 from AI Solutions, Inc.

2. Landsat-7 / Flight Dynamics Interface Control Document, Revision Number 1, September, 1997, 553-FDD-95/003R1UD0 and 430-11-06-006-1

3. Landsat 7 System Zero-R Distribution Product Data Format Control Book, Volume 5, Book 1

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